CHAPTER TWO

Data Preparation

Manual of Risk Assessment for Contaminant Intrusion into Water Distribution System

Chapter-1
IRA-WDS: Overview

Chapter-2
Data Preparation

Chapter-3
Contaminant Ingress Model

Chapter-4
Pipe Condition Assessment Model

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Risk Assessment Model

Chapter 2: Data Preparation

2.1 Introduction

Data preparation for the IRA-WDS program involves two major steps:

1. The creation of appropriate shape files: these are GIS files that contain the spatial information on all objects considered by the IRA-WDS program; and
2. Input of additional model data: these files contain specific characteristics of the objects generated in the shape files.

2.2 Creating shape files

The first step in using IRA-WDS is to create a series of **shape files** (for ArcView). These shape files contain spatial information on the various objects considered by IRA-WDS. These include: pollution sources, water distribution systems, base maps (that is, infrastructure and contour maps) and environmental maps (for example, soil type, groundwater and so on). The shape files are generated by digitizing maps containing the various objects (pollution sources, water distribution systems, base maps etc.); see Figures 2.1 and 2.2, below. Shape files can be divided into two categories:

- Thematic layers: base maps and environmental maps; and
- Network databases: pollution sources and water distribution systems.

As mentioned above, pollution sources and water distribution pipes are all represented as networks within IRA-WDS. For the purposes of modelling, the geometry of the networks has to be expressed as a network consisting of links and nodes. The links and nodes act as a framework on which all other kinds of relevant information are hung. The shape files so generated contain the following information:

- Nodal shape files: *Node id, x-coord, y-coord* and *Elevation*; and
- Link shape files: *Link id, Start node, End node* and *Length.*

The shape files required for IRA-WDS are as follows:

- Sewer node and link shape files;
- Canal node and link shape files;
- Foul surface water body node and link shape files; and
- Water distribution node and link shape files.

Note that in the user's working directory, each shape file generated will have five separate files associated with it with the following extensions: **.shp, *.shr, *.sbx, *.spn* and **.dbf*. For example, a sewer node shape file will have five associated files.

Among these five files, the most important ones are the '**shp**' and '**dbf**' files:

- The 'shp' files are uploaded through the GIS interface to run the program; and
- The 'dbf' files contain all the attribute data for nodes and links. These files are expanded during the data preparation stage (described in Section 2.3), to include specific characteristics of the nodes and links.

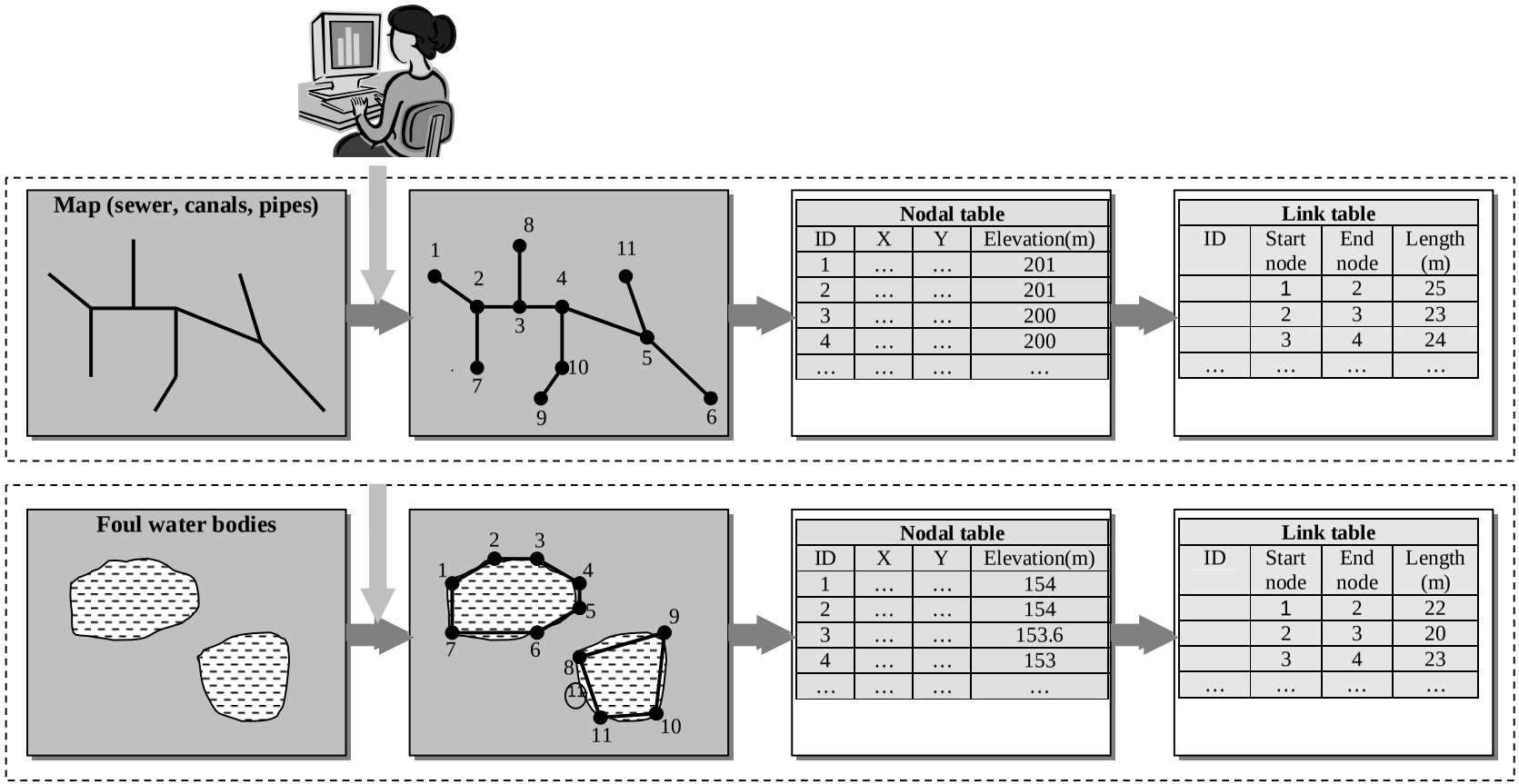


Figure 2.1. Digitization of real-world network

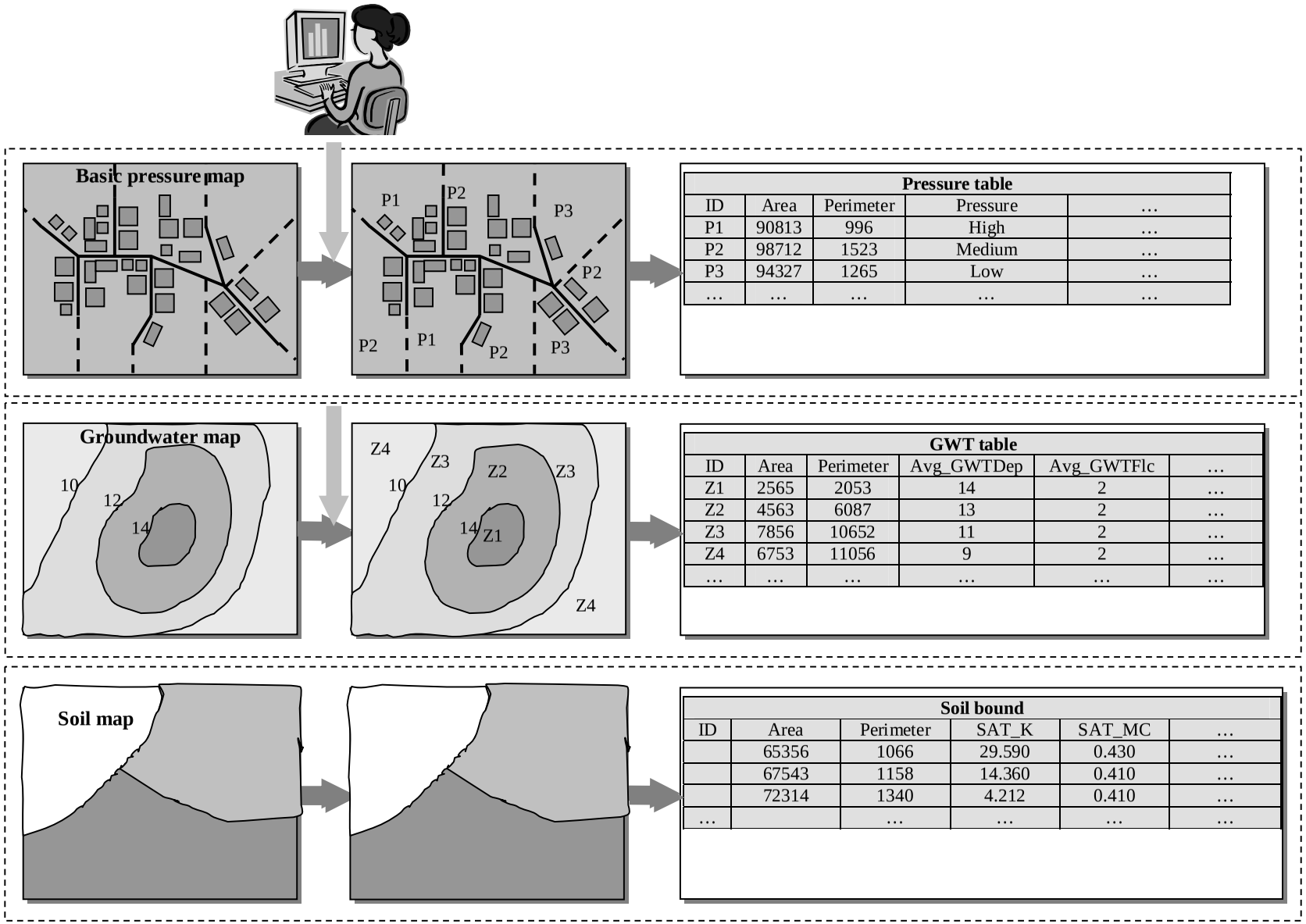


Figure 2.2. Digitization of thematic maps

Output
On completion of this step (creating shape-files) a number of shape files will have been created. These may include:

Thematic Layers

- Base maps:
  - Infrastructure – *Line and Polygon shape files*
  - Contour – *Line shape files*
- Environmental maps:
  - Soil – *Polygon shape files*
  - Groundwater – *Polygon shape files*
  - Pressure – *Polygon shape files*

Network databases

- Sewer – *Node and Link shape files*
- Canal – *Node and Link shape files*
- Foul water body – *Node and Link shape files*
- Water distribution – *Node and Link shape files*

2.3 Input of additional model data

2.3.1 Enclosed Excel spreadsheet (DataInput.xls)

In this section, details of how to add additional node and link data to the shape files are presented. To assist in this, an Excel file has been included with IRA-WDS (DataInput.xls) that contains a template. Figure 2.3, below, shows example worksheets from the Excel file.

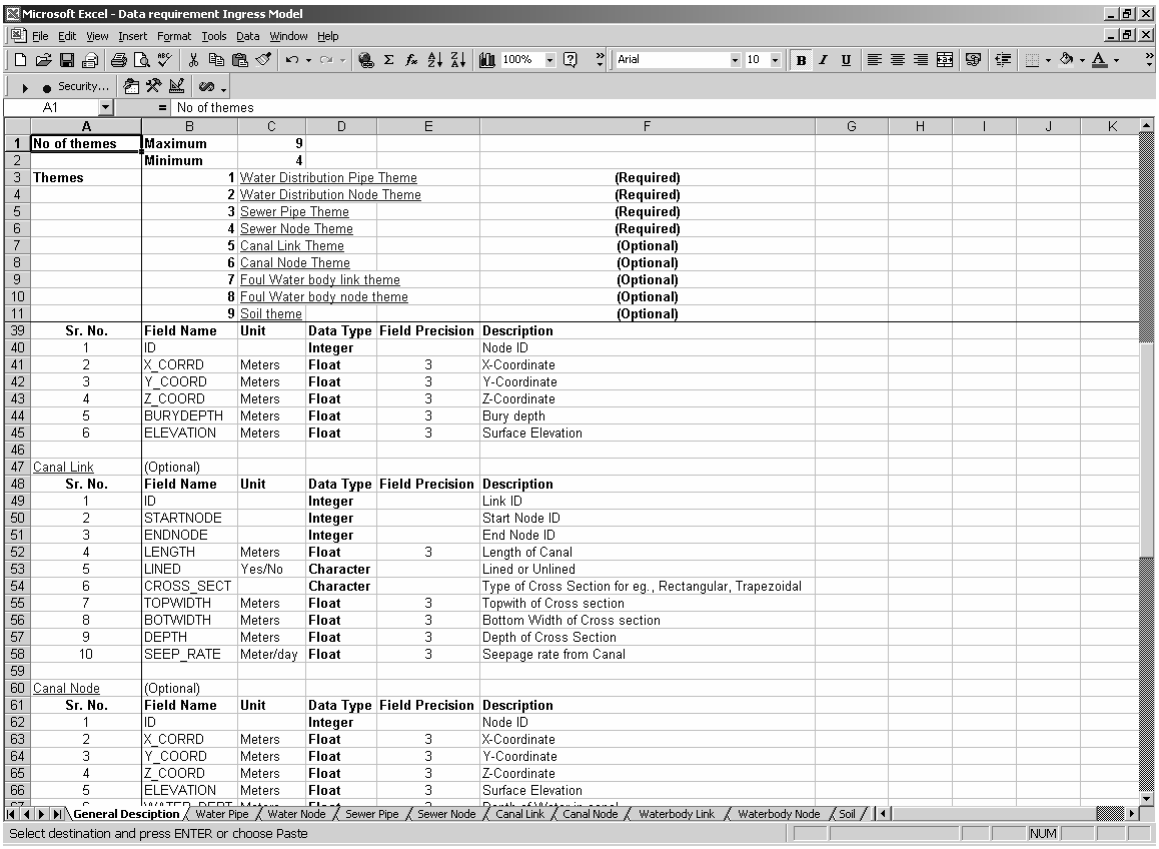
The first thing for the user to do is to copy this Excel file into his or her working directory and rename it as appropriate (for example, the project name). The Excel spread sheet contains several worksheets to assist with data entry.

The first worksheet labelled 'General Description' gives an overview of all the other worksheets and provides information on data requirements for those other worksheets (see Figure 2.3). Hyperlinks are provided in this worksheet to help navigate between the other worksheets.

In addition to the General Description worksheet, there are 12 other worksheets (see the tabs at the bottom of the worksheet shown in Figure 2.3). In each of these 12 worksheets, attribute data for the various objects are added by the user. On completion of these worksheets, the data contained in them are then transferred to the objects' respective shape files (details of how this is done is given in Section 2.4).

Note that this Excel spreadsheet has several columns in each worksheet, where the data have already been generated and stored in the shape files (in the file with extension dbf). These data mainly relate to the spatial location of the objects, but also include information related to elevation and lengths of links.

Therefore the authors suggest that the data from the shape files (dbf) are copied and pasted into the appropriate worksheet of the Excel file.



	A	B	C	D	E	F
1	No of themes	Maximum	9			
2		Minimum	4			
3	Themes	1	Water Distribution Pipe Theme			(Required)
4		2	Water Distribution Node Theme			(Required)
5		3	Sewer Pipe Theme			(Required)
6		4	Sewer Node Theme			(Required)
7		5	Canal Link Theme			(Optional)
8		6	Canal Node Theme			(Optional)
9		7	Foul Water body link theme			(Optional)
10		8	Foul Water body node theme			(Optional)
11		9	Soil theme			(Optional)
39	Sr. No.	Field Name	Unit	Data Type	Field Precision	Description
40	1	ID		Integer		Node ID
41	2	X_CORRD	Meters	Float	3	X-Coordinate
42	3	Y_COORD	Meters	Float	3	Y-Coordinate
43	4	Z_COORD	Meters	Float	3	Z-Coordinate
44	5	BURYDEPTH	Meters	Float	3	Bury depth
45	6	ELEVATION	Meters	Float	3	Surface Elevation
46						
47	Canal Link	(Optional)				
48	Sr. No.	Field Name	Unit	Data Type	Field Precision	Description
49	1	ID		Integer		Link ID
50	2	STARTNODE		Integer		Start Node ID
51	3	ENDNODE		Integer		End Node ID
52	4	LENGTH	Meters	Float	3	Length of Canal
53	5	LINED	Yes/No	Character		Lined or Unlined
54	6	CROSS_SECT		Character		Type of Cross Section for eg., Rectangular, Trapezoidal
55	7	TOPWIDTH	Meters	Float	3	Topwith of Cross section
56	8	BOTWIDTH	Meters	Float	3	Bottom Width of Cross section
57	9	DEPTH	Meters	Float	3	Depth of Cross Section
58	10	SEEP_RATE	Meter/day	Float	3	Seepage rate from Canal
59						
60	Canal Node	(Optional)				
61	Sr. No.	Field Name	Unit	Data Type	Field Precision	Description
62	1	ID		Integer		Node ID
63	2	X_CORRD	Meters	Float	3	X-Coordinate
64	3	Y_COORD	Meters	Float	3	Y-Coordinate
65	4	Z_COORD	Meters	Float	3	Z-Coordinate
66	5	ELEVATION	Meters	Float	3	Surface Elevation

Figure 2.3. Enclosed Excel file DataInput.xls

2.3.2 Contaminant Ingress Model

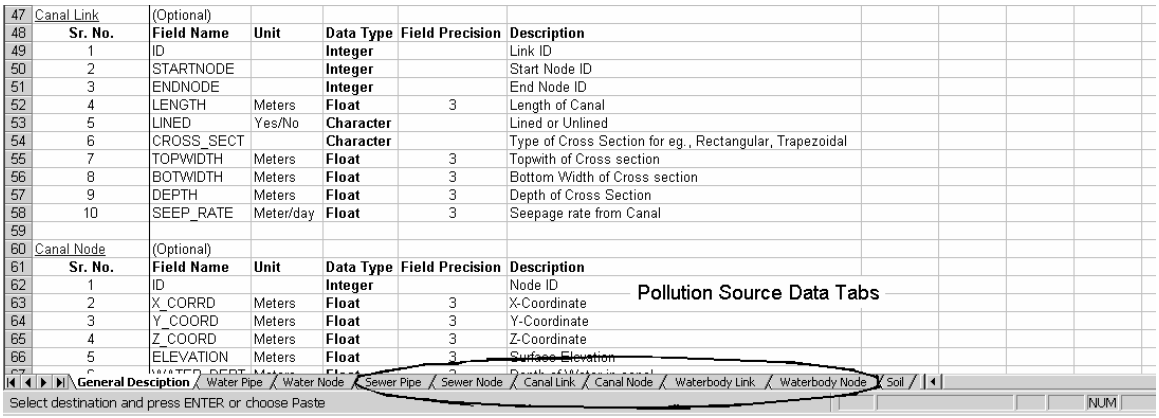
The data required for the Contaminant Ingress Model are as follows:

- Pollutant sources;
- Water distribution pipes; and
- Environmental data (soil type and so on).

2.3.2.1 Pollutant sources

IRA-WDS considers the following pollutant sources: sewers/drains, canals and ponds/ditches. As described earlier, the spatial information about the pollution sources is contained in the generated shape files. This section provides details on how additional attribute data are added.

Figure 2.4, below, shows the relevant worksheet for pollutant sources from the enclosed Excel file.

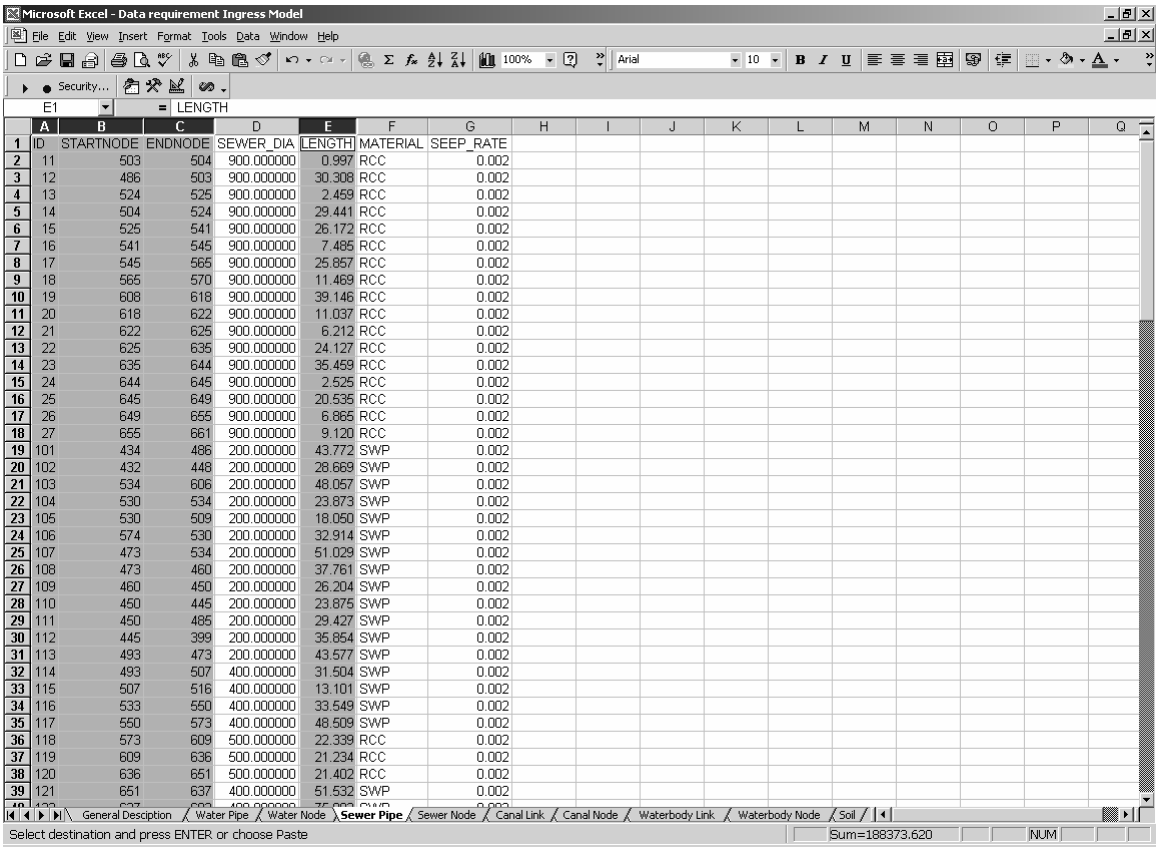


47	Canal Link	(Optional)				
48	**Sr. No.**	**Field Name**	**Unit**	**Data Type**	**Field Precision**	**Description**
49	1	ID		**Integer**		Link ID
50	2	STARTNODE		**Integer**		Start Node ID
51	3	ENDNODE		**Integer**		End Node ID
52	4	LENGTH	Meters	**Float**	3	Length of Canal
53	5	LINED	Yes/No	**Character**		Lined or Unlined
54	6	CROSS_SECT		**Character**		Type of Cross Section for eg., Rectangular, Trapezoidal
55	7	TOPWIDTH	Meters	**Float**	3	Topwith of Cross section
56	8	BOTWIDTH	Meters	**Float**	3	Bottom Width of Cross section
57	9	DEPTH	Meters	**Float**	3	Depth of Cross Section
58	10	SEEP_RATE	Meter/day	**Float**	3	Seepage rate from Canal
59						
60	Canal Node	(Optional)				
61	**Sr. No.**	**Field Name**	**Unit**	**Data Type**	**Field Precision**	**Description**
62	1	ID		**Integer**		Node ID
63	2	X_CORRD	Meters	**Float**	3	X-Coordinate
64	3	Y_COORD	Meters	**Float**	3	Y-Coordinate
65	4	Z_COORD	Meters	**Float**	3	Z-Coordinate
66	5	ELEVATION	Meters	**Float**	3	Surface Elevation

Figure 2.4. Worksheet for pollutant sources

At this stage:

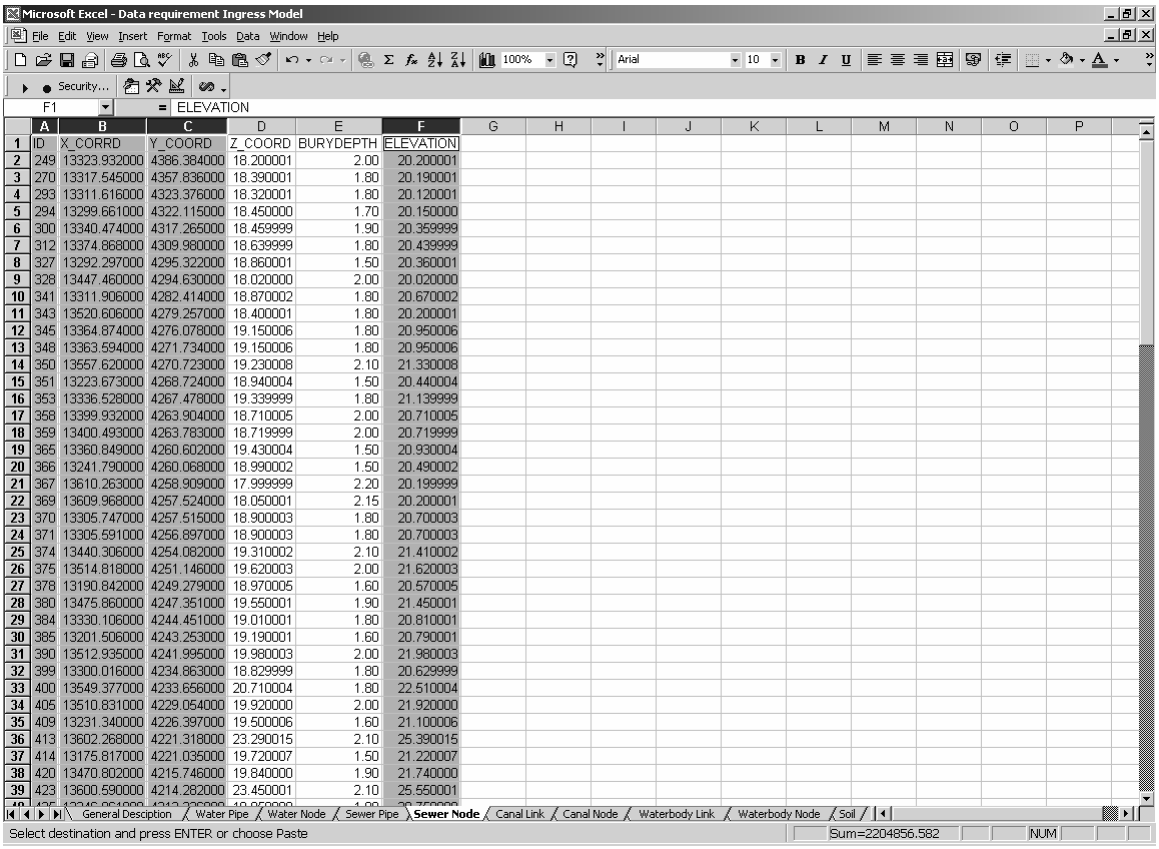
- The Excel spreadsheet should have been saved in the user's working directory; and
- The shaded columns shown in Figures 2.5 and Figure 2.6 should be filled from the data in the dbf shape files (see Section 2.4).



ID	STARTNODE	ENDNODE	SEWER_DIA	LENGTH	MATERIAL	SEEP_RATE
11	503	504	900.000000	0.997	RCC	0.002
12	486	503	900.000000	30.308	RCC	0.002
13	524	525	900.000000	2.459	RCC	0.002
14	504	524	900.000000	29.441	RCC	0.002
15	525	541	900.000000	26.172	RCC	0.002
16	541	545	900.000000	7.485	RCC	0.002
17	545	565	900.000000	25.857	RCC	0.002
18	565	570	900.000000	11.469	RCC	0.002
19	608	618	900.000000	39.146	RCC	0.002
20	618	622	900.000000	11.037	RCC	0.002
21	622	625	900.000000	6.212	RCC	0.002
22	625	635	900.000000	24.127	RCC	0.002
23	635	644	900.000000	35.459	RCC	0.002
24	644	645	900.000000	2.525	RCC	0.002
25	645	649	900.000000	20.535	RCC	0.002
26	649	655	900.000000	6.865	RCC	0.002
27	655	661	900.000000	9.120	RCC	0.002
101	434	486	200.000000	43.772	SWP	0.002
102	432	448	200.000000	28.669	SWP	0.002
103	534	606	200.000000	48.057	SWP	0.002
104	530	534	200.000000	23.873	SWP	0.002
105	530	509	200.000000	18.050	SWP	0.002
106	574	530	200.000000	32.914	SWP	0.002
107	473	534	200.000000	51.029	SWP	0.002
108	473	460	200.000000	37.761	SWP	0.002
109	460	450	200.000000	26.204	SWP	0.002
110	450	445	200.000000	23.875	SWP	0.002
111	450	485	200.000000	29.427	SWP	0.002
112	445	399	200.000000	35.854	SWP	0.002
113	493	473	200.000000	43.577	SWP	0.002
114	493	507	400.000000	31.504	SWP	0.002
115	507	516	400.000000	13.101	SWP	0.002
116	533	550	400.000000	33.549	SWP	0.002
117	550	573	400.000000	48.509	SWP	0.002
118	573	609	500.000000	22.339	RCC	0.002
119	609	636	500.000000	21.234	RCC	0.002
120	636	651	500.000000	21.402	RCC	0.002
121	651	637	400.000000	51.532	SWP	0.002

Figure 2.5. Link data entry for sewer

The next stage is for the user to complete the remaining fields on the worksheets (that is, the unshaded columns of the tables in Figures 2.5 and 2.6). Tables 2.1 and 2.2, below, give details of the additional attributes required for link data and node data respectively for the sewer.



ID	X_CORRD	Y_COORD	Z_COORD	BURYDEPTH	ELEVATION
249	13323.932000	4386.384000	18.200001	2.00	20.200001
270	13317.545000	4357.836000	18.390001	1.80	20.190001
293	13311.616000	4323.376000	18.320001	1.80	20.120001
294	13299.661000	4322.115000	18.450000	1.70	20.150000
300	13340.474000	4317.265000	18.459999	1.90	20.359999
312	13374.868000	4309.980000	18.639999	1.80	20.439999
327	13292.297000	4295.322000	18.860001	1.50	20.360001
328	13447.460000	4294.630000	18.020000	2.00	20.020000
341	13311.906000	4282.414000	18.870002	1.80	20.670002
343	13520.606000	4279.257000	18.400001	1.80	20.200001
345	13364.874000	4276.078000	19.150006	1.80	20.950006
348	13363.594000	4271.734000	19.150006	1.80	20.950006
350	13557.620000	4270.723000	19.230008	2.10	21.330008
351	13223.673000	4268.724000	18.940004	1.50	20.440004
353	13336.528000	4267.478000	19.339999	1.80	21.139999
358	13399.932000	4263.904000	18.710005	2.00	20.710005
359	13400.493000	4263.783000	18.719999	2.00	20.719999
365	13360.849000	4260.602000	19.430004	1.50	20.930004
366	13241.790000	4260.068000	18.990002	1.50	20.490002
367	13610.263000	4258.909000	17.999999	2.20	20.199999
369	13609.968000	4257.524000	18.050001	2.15	20.200001
370	13305.747000	4257.515000	18.900003	1.80	20.700003
371	13305.591000	4256.897000	18.900003	1.80	20.700003
374	13440.306000	4254.082000	19.310002	2.10	21.410002
375	13514.818000	4251.146000	19.620003	2.00	21.620003
378	13190.842000	4249.279000	18.970005	1.60	20.570005
380	13475.860000	4247.351000	19.550001	1.90	21.450001
384	13330.106000	4244.451000	19.010001	1.80	20.810001
385	13201.506000	4243.253000	19.190001	1.60	20.790001
390	13512.935000	4241.995000	19.980003	2.00	21.980003
399	13300.016000	4234.863000	18.829999	1.80	20.629999
400	13549.377000	4233.656000	20.710004	1.80	22.510004
405	13510.831000	4229.054000	19.920000	2.00	21.920000
409	13231.340000	4226.397000	19.500006	1.60	21.100006
413	13602.268000	4221.318000	23.290015	2.10	25.390015
414	13175.817000	4221.035000	19.720007	1.50	21.220007
420	13470.802000	4215.746000	19.840000	1.90	21.740000
423	13600.590000	4214.282000	23.450001	2.10	25.550001

Figure 2.6. Node data entry for sewer

Table 2.1. Sewer link data for Contaminant Ingress Model		
Field name	**Unit**	**Description**
SEWER_DIA	*mm*	Sewer diameter
SEEP_RATE	*Metre/day*	Seepage rate from sewer pipe

Table 2.2. Sewer node data for Contaminant Ingress Model		
Field name	**Unit**	**Description**
BURYDEPTH	*Metres*	Buried depth of node

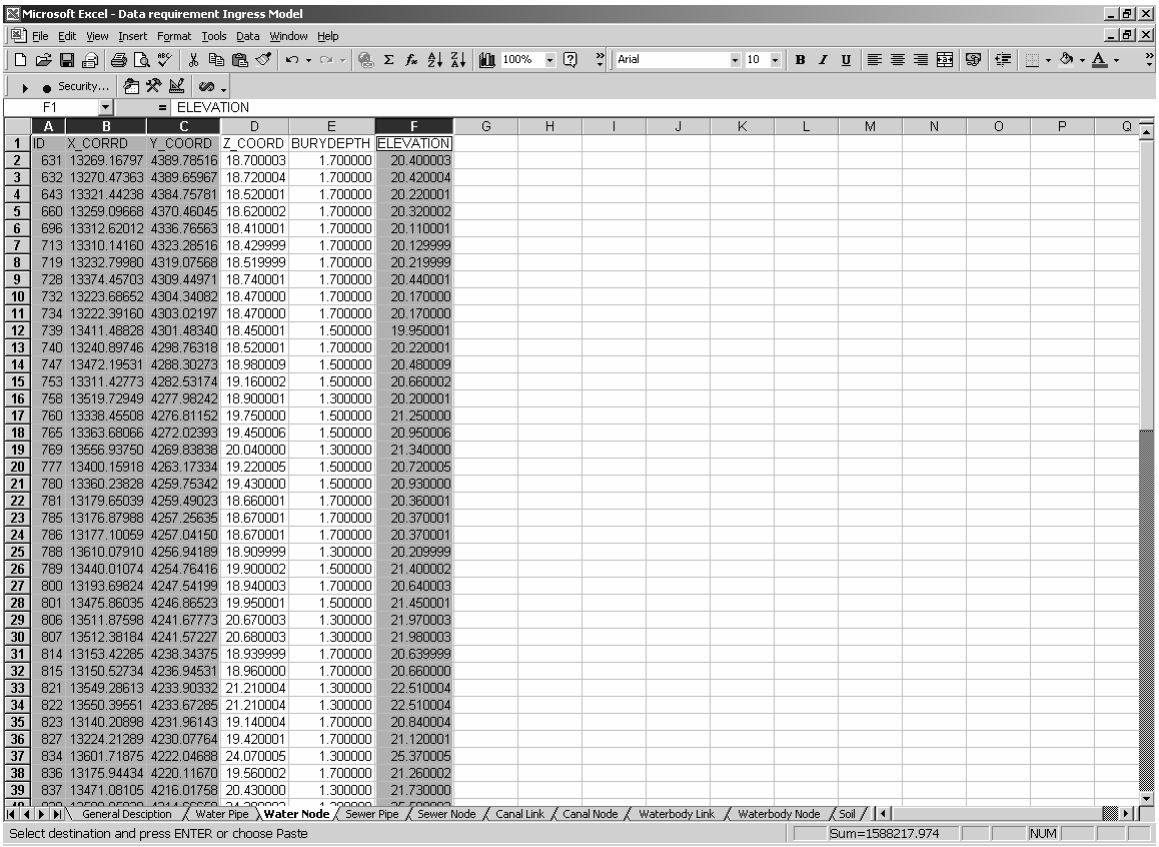
2.3.2.2 Water distribution system

In addition to pollutant sources, IRA-WDS requires additional attribute data for the water distribution system. As described earlier, the spatial information about the water distribution system (WDS) is contained in the shape files generated earlier. In this section, details are given on how additional attribute data are added.

Figure 2.7, below, shows the relevant worksheet from the enclosed Excel file for the water distribution system. At this stage, the shaded columns shown in Figure 2.7 should have been filled from the data in the dbf shape files (see Section 2.4).

The next stage is for the user to complete the remaining fields on the worksheets (the unshaded columns of the table in Figure 2.7). For details, see Table 2.3.

Table 2.3. WDS node data for Contaminant Ingress Model		
Field name	**Unit**	**Description**
BURYDEPTH	*Metres*	Bury depth
Z- Coordinate	*Metres*	Surface elevation



ID	X_CORRD	Y_COORD	Z_COORD	BURYDEPTH	ELEVATION
631	13269.16797	4389.78516	18.700003	1.700000	20.400003
632	13270.47363	4389.65967	18.720004	1.700000	20.420004
643	13321.44238	4384.75781	18.520001	1.700000	20.220001
660	13259.09668	4370.46045	18.620002	1.700000	20.320002
696	13312.62012	4336.76563	18.410001	1.700000	20.110001
713	13310.14160	4323.28516	18.429999	1.700000	20.129999
719	13232.79980	4319.07568	18.519999	1.700000	20.219999
728	13374.45703	4309.44971	18.740001	1.700000	20.440001
732	13223.68652	4304.34082	18.470000	1.700000	20.170000
734	13222.39160	4303.02197	18.470000	1.700000	20.170000
739	13411.48828	4301.48340	18.450001	1.500000	19.950001
740	13240.89746	4298.76318	18.520001	1.700000	20.220001
747	13472.19531	4288.30273	18.980009	1.500000	20.480009
753	13311.42773	4282.53174	19.160002	1.500000	20.660002
758	13519.72949	4277.98242	18.900001	1.300000	20.200001
760	13338.45508	4276.81152	19.750000	1.500000	21.250000
765	13363.68066	4272.02393	19.450006	1.500000	20.950006
769	13556.93750	4269.83838	20.040000	1.300000	21.340000
777	13400.15918	4263.17334	19.220005	1.500000	20.720005
780	13360.23828	4259.75342	19.430000	1.500000	20.930000
781	13179.65039	4259.49023	18.660001	1.700000	20.360001
785	13176.87988	4257.25635	18.670001	1.700000	20.370001
786	13177.10059	4257.04150	18.670001	1.700000	20.370001
788	13610.07910	4256.94189	18.909999	1.300000	20.209999
789	13440.01074	4254.76416	19.900002	1.500000	21.400002
800	13193.69824	4247.54199	18.940003	1.700000	20.640003
801	13475.86035	4246.86523	19.950001	1.500000	21.450001
806	13511.87598	4241.67773	20.670003	1.300000	21.970003
807	13512.38184	4241.57227	20.680003	1.300000	21.980003
814	13153.42285	4238.34375	18.939999	1.700000	20.639999
815	13150.52734	4236.94531	18.960000	1.700000	20.660000
821	13549.28613	4233.90332	21.210004	1.300000	22.510004
822	13550.39551	4233.67285	21.210004	1.300000	22.510004
823	13140.20898	4231.96143	19.140004	1.700000	20.840004
827	13224.21289	4230.07764	19.420001	1.700000	21.120001
834	13601.71875	4222.04688	24.070005	1.300000	25.370005
836	13175.94434	4220.11670	19.560002	1.700000	21.260002
837	13471.08105	4216.01758	20.430000	1.300000	21.730000

Figure 2.7. Node data entry for water distribution system

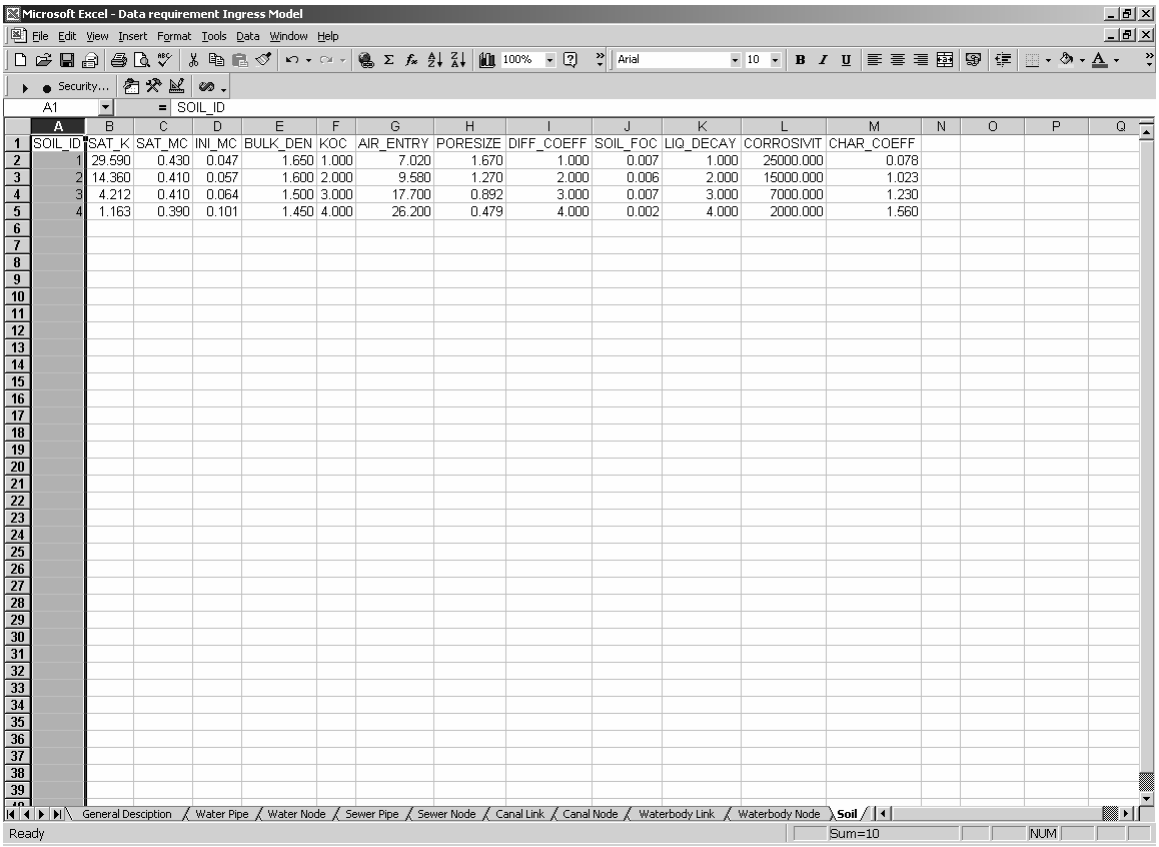
2.3.2.3 Environmental factors

In addition to the pollutant sources and water distribution system, IRA-WDS requires information on soil characteristics. Shape files have already been constructed for soil data, groundwater and pressure zones. In this section, details on are given how additional attribute data are added.

Figure 2.8, below, shows the relevant worksheet from the enclosed Excel file for soil characteristics. At this stage, the shaded columns shown in Figure 2.8 should have already been filled from the data in the dbf shape files (see Section 2.4).

The next stage is for the user to complete the remaining fields on the worksheets (the unshaded columns of the table in Figure 2.8). For details, see Table 2.4.

Table 2.4. Soil data for Contaminant Ingress Model		
Field name	**Unit**	**Description**
SAT_K	*cm/hr*	Saturated hydraulic conductivity
SAT_MC		Saturated moisture content
INI_MC		Initial moisture content
BULK_DEN	*gm/cm*^{3}	Bulk density
KOC		Soil organic carbon coefficient
AIR_ENTRY	*cm*	Air entry head
PORESIZE		Pore size index
DIFF_COEFF	*cm*^{2}*/day*	Diffusion coefficient
SOIL_FOC		Soil fraction of organic content
LIQ_DECAY	*per hr*	Liquid phase decay
CHAR_COEFF		Soil characteristic curve coefficient



SOIL_ID	SAT_K	SAT_MC	INI_MC	BULK_DEN	KOC	AIR_ENTRY	PORESIZE	DIFF_COEFF	SOIL_FOC	LIQ_DECAY	CORROSIVIT	CHAR_COEFF
1	29.590	0.430	0.047	1.650	1.000	7.020	1.670	1.000	0.007	1.000	25000.000	0.078
2	14.360	0.410	0.057	1.600	2.000	9.580	1.270	2.000	0.006	2.000	15000.000	1.023
3	4.212	0.410	0.064	1.500	3.000	17.700	0.892	3.000	0.007	3.000	7000.000	1.230
4	1.163	0.390	0.101	1.450	4.000	26.200	0.479	4.000	0.002	4.000	2000.000	1.560

Figure 2.8. Soil data entry

2.3.3 Pipe Condition Assessment Model

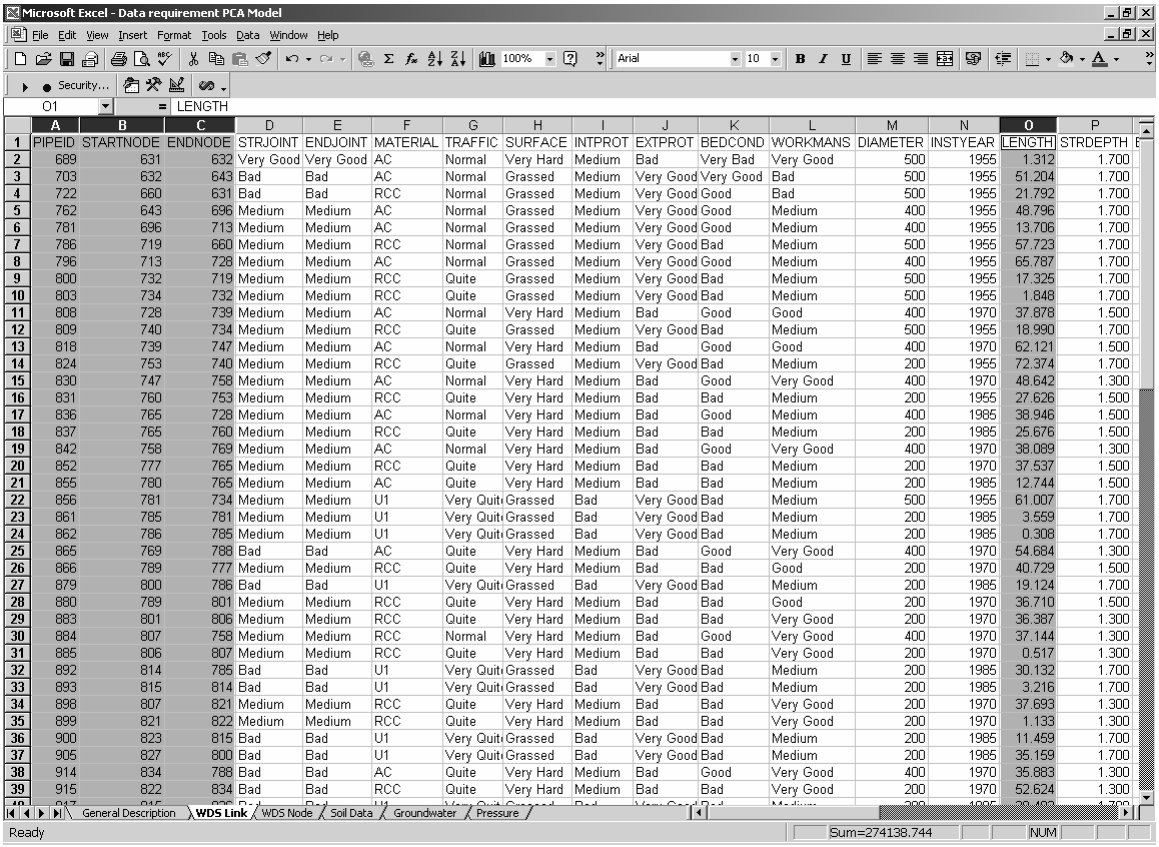
Data requirements for the Pipe Condition Assessment Model are related to the factors that affect the condition of the pipe. A description of these various factors and how they are represented in the model can be found in Chapter 3, below.

It should be noted that this model requires some data in the form of fuzzy (qualitative) numbers (such as link joint type, surface type, traffic load and so on) and others as crisp (quantitative) numbers (such as link material, diameter, length and so on). Therefore the data in the form of fuzzy numbers will require the user to input fuzzy membership functions. Table 3.1 in Chapter 3 of Book 3 shows which data is fuzzy and which is crisp.

Figure 2.9, below, shows the relevant worksheet from the enclosed Excel file for the Pipe Condition Assessment Model. At this stage, the shaded columns shown in Figure 2.9 should have already been filled from the data in the dbf shape files (see Section 2.4) and during data preparation for the Contaminant Ingress Model. The next stage is for the user to complete the remaining fields on the worksheets (the unshaded columns in Figure 2.9 and Table 2.5).

Table 2.5. WDS link data for Pipe Condition Assessment Model

Field name	Unit	Description
STRJOINT		Joint method at start node
ENDJOINT		Joint method at end node
MATERIAL		Material type
TRAFFIC		Traffic load
SURFACE		Surface type
INTPROT		Internal protection
EXTPROT		External protection
BEDCOND		Bedding condition
WORKMANS		Workmanship
DIAMETER	*mm*	Diameter of pipe
INSTYEAR	*yyyy*	Installation year
LENGTH	*Metres*	Length of pipe
STRDEPTH	*Metres*	Start node bury depth
ENDDEPTH	*Metres*	End node bury depth
NOCONNEC		No. of pipes joined with diameter less than minimum considered
BREAKAGE	*Per year*	No. of breaks per year
LEAKAGE	*lps*	Leakage rate
VALVES		No. of valves
DURATION	*Hrs/day*	Duration of water supply per day
NOOPER	*Per day*	No. of times water supplied per day



PIPEID	STARTNODE	ENDNODE	STRJOINT	ENDJOINT	MATERIAL	TRAFFIC	SURFACE	INTPROT	EXTPROT	BEDCOND	WORKMANS	DIAMETER	INSTYEAR	LENGTH	STRDEPTH
689	631	632	Very Good	Very Good	AC	Normal	Very Hard	Medium	Bad	Very Bad	Very Good	500	1955	1.312	1.700
703	632	643	Bad	Bad	AC	Normal	Grassed	Medium	Very Good	Very Good	Bad	500	1955	51.204	1.700
722	660	631	Bad	Bad	RCC	Normal	Grassed	Medium	Very Good	Good	Bad	500	1955	21.792	1.700
762	643	696	Medium	Medium	AC	Normal	Grassed	Medium	Very Good	Good	Medium	400	1955	48.796	1.700
781	696	713	Medium	Medium	AC	Normal	Grassed	Medium	Very Good	Good	Medium	400	1955	13.706	1.700
786	719	660	Medium	Medium	RCC	Normal	Grassed	Medium	Very Good	Bad	Medium	500	1955	57.723	1.700
796	713	728	Medium	Medium	AC	Normal	Grassed	Medium	Very Good	Good	Medium	400	1955	65.787	1.700
800	732	719	Medium	Medium	RCC	Quite	Grassed	Medium	Very Good	Bad	Medium	500	1955	17.325	1.700
803	734	732	Medium	Medium	RCC	Quite	Grassed	Medium	Very Good	Bad	Medium	500	1955	1.848	1.700
808	728	739	Medium	Medium	AC	Normal	Very Hard	Medium	Bad	Good	Good	400	1970	37.878	1.500
809	740	734	Medium	Medium	RCC	Quite	Grassed	Medium	Very Good	Bad	Medium	500	1955	18.990	1.700
818	739	747	Medium	Medium	AC	Normal	Very Hard	Medium	Bad	Good	Good	400	1970	62.121	1.500
824	753	740	Medium	Medium	RCC	Quite	Grassed	Medium	Very Good	Bad	Medium	200	1955	72.374	1.700
830	747	758	Medium	Medium	AC	Normal	Very Hard	Medium	Bad	Good	Very Good	400	1970	48.642	1.300
831	760	753	Medium	Medium	RCC	Quite	Very Hard	Medium	Bad	Bad	Medium	200	1955	27.626	1.500
836	765	728	Medium	Medium	AC	Normal	Very Hard	Medium	Bad	Good	Medium	400	1985	38.946	1.500
837	765	760	Medium	Medium	RCC	Quite	Very Hard	Medium	Bad	Bad	Medium	200	1985	25.676	1.500
842	758	769	Medium	Medium	AC	Normal	Very Hard	Medium	Bad	Good	Very Good	400	1970	38.089	1.300
852	777	765	Medium	Medium	RCC	Quite	Very Hard	Medium	Bad	Bad	Medium	200	1970	37.537	1.500
855	780	765	Medium	Medium	AC	Quite	Very Hard	Medium	Bad	Bad	Medium	200	1985	12.744	1.500
856	781	734	Medium	Medium	U1	Very Quit	Grassed	Bad	Very Good	Bad	Medium	500	1955	61.007	1.700
861	785	781	Medium	Medium	U1	Very Quit	Grassed	Bad	Very Good	Bad	Medium	200	1985	3.559	1.700
862	786	785	Medium	Medium	U1	Very Quit	Grassed	Bad	Very Good	Bad	Medium	200	1985	0.308	1.700
865	769	788	Bad	Bad	AC	Quite	Very Hard	Medium	Bad	Good	Very Good	400	1970	54.684	1.300
866	789	777	Medium	Medium	RCC	Quite	Very Hard	Medium	Bad	Bad	Good	200	1970	40.729	1.500
879	800	786	Bad	Bad	U1	Very Quit	Grassed	Bad	Very Good	Bad	Medium	200	1985	19.124	1.700
880	789	801	Medium	Medium	RCC	Quite	Very Hard	Medium	Bad	Bad	Good	200	1970	36.710	1.500
883	801	806	Medium	Medium	RCC	Quite	Very Hard	Medium	Bad	Bad	Very Good	200	1970	36.387	1.300
884	807	758	Medium	Medium	RCC	Normal	Very Hard	Medium	Bad	Good	Very Good	400	1970	37.144	1.300
885	806	807	Medium	Medium	RCC	Quite	Very Hard	Medium	Bad	Bad	Very Good	200	1970	0.517	1.300
892	814	785	Bad	Bad	U1	Very Quit	Grassed	Bad	Very Good	Bad	Medium	200	1985	30.132	1.700
893	815	814	Bad	Bad	U1	Very Quit	Grassed	Bad	Very Good	Bad	Medium	200	1985	3.216	1.700
898	807	821	Medium	Medium	RCC	Quite	Very Hard	Medium	Bad	Bad	Very Good	200	1970	37.693	1.300
899	821	822	Medium	Medium	RCC	Quite	Very Hard	Medium	Bad	Bad	Very Good	200	1970	1.133	1.300
900	823	815	Bad	Bad	U1	Very Quit	Grassed	Bad	Very Good	Bad	Medium	200	1985	11.459	1.700
905	827	800	Bad	Bad	U1	Very Quit	Grassed	Bad	Very Good	Bad	Medium	200	1985	35.159	1.700
914	834	788	Bad	Bad	AC	Quite	Very Hard	Medium	Bad	Good	Very Good	400	1970	35.883	1.300
915	822	834	Bad	Bad	RCC	Quite	Very Hard	Medium	Bad	Bad	Very Good	200	1970	52.624	1.300

Figure 2.9. Water distribution pipe condition assessment data

2.4 Creating a dbf

At this stage, all data for the model have been completed and entered into the Excel spreadsheet provided. This Excel file should have been stored in the working directory for the project.

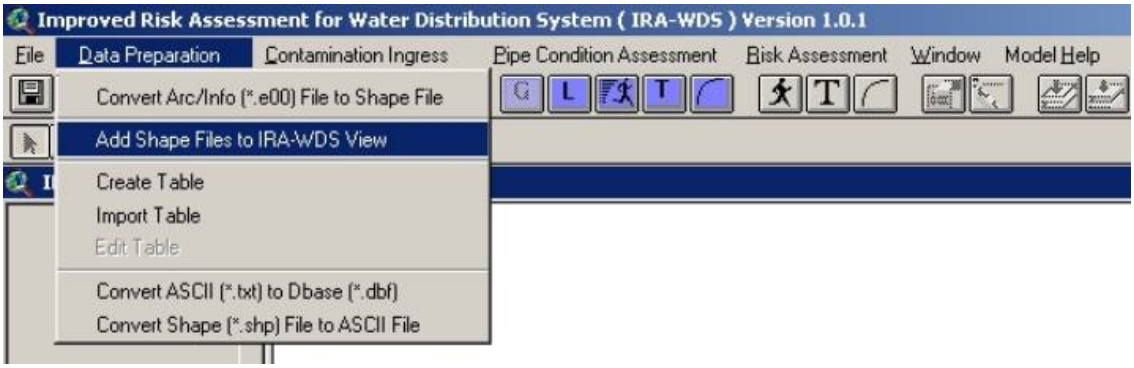
The next step is for the user to link the data in the Excel spreadsheet with the relevant shape files. In order to achieve this, each worksheet from the Excel spreadsheet must be saved as a dbf file with a filename identical to the relevant shape file.

For example, to create the link data shape file for a water distribution system:

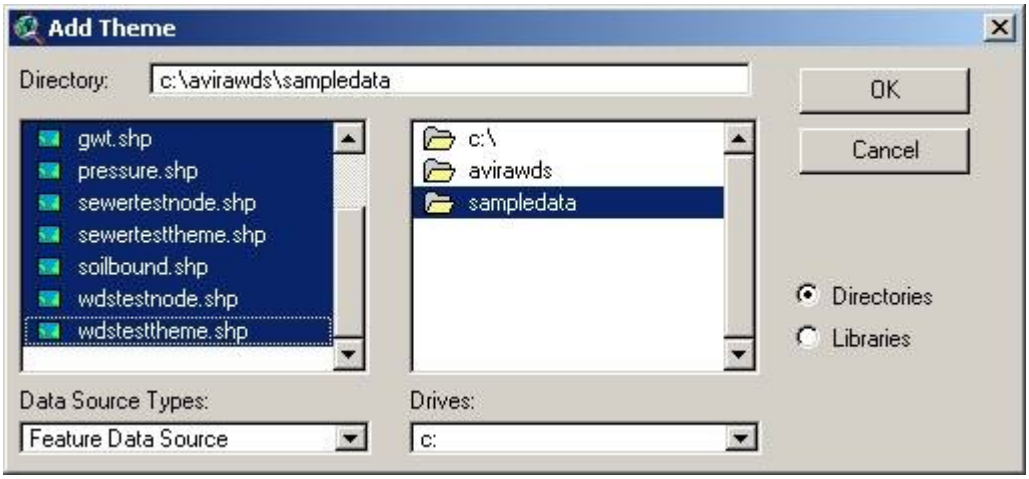
1. If the name of the shape file is ‘waterpipe.shp’
2. In the Excel spreadsheet select the ‘WDSlink’ worksheet
3. While this worksheet is active, do the following:
   - File – Save As: ‘waterpipe.dbf’ (this name is the same as the shape file)
   - Make sure the file is saved to the working directory (that contains the shape files)
   - Note: the original ‘waterpipe.dbf’ file will be overwritten with the new dbf file. Therefore, make sure all the information in the original dbf file has been copied to the new one.

2.5 Add shape files to GIS

The next step is for the user to add the necessary shape files to IRA-WDS, so that the data can be viewed and used by the three models (the Contamination Ingress Model, Pipe Condition Assessment Model and Risk Assessment Model). This can be done by clicking on the Tool icon which is just below the 'Data Preparation' menu or by clicking on the 'Data Preparation' menu and then clicking on the submenu 'Add Shape Files to IRA-WDS View', as shown in the screen below:



This opens the 'Add Theme' form, as shown below:



After the user selects the shape files to be added to the IRA-WDS View, he/she can click on the 'OK' button, which will load the shape files to the IRA-WDS View, and corresponding dbf files in the Table GUI of the ArcView.